Diffraction imaging for seal evaluation using ultra high resolution 3D seismic data

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A.Klokov
R.H.Trevino
T.A. Meckel

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Abstract

Cap rock is any impermeable or low permeability formation that may trap oil, gas or water, preventing it from migrating to the surface. Evaluation of sealing properties of the cap rock is a critical task for seismic exploration. It is important for oil and gas prospecting as well as for locating reservoirs appropriate for carbon dioxide storage. The latter has been proposed as one solution to global climate change caused by heat-trapping anthropogenic gasses in the atmosphere. A fluid escaped from the reservoir fills voids in the overlying strata thereby causing local changes of acoustic properties. We aim to explore such fluid-saturated areas and thus evaluate sealing properties of underlying cap rocks. We assume that local acoustic impedance changes caused by fluid migration generate seismic diffractions. We isolate diffracted waves from P-Cable seismic data acquired over the area of interest and perform diffraction analysis of the near-surface interval (above 200 m).

In the diffraction image obtained, we interpret an extensive system of broad sinuous channels, narrow linear faults, and diffuse fracture networks. In addition, we detect high-diffractivity anomalies, which extend vertically and laterally. We note no evidence of these anomalies in a conventional seismic image and associated seismic attribute (similarity and fracture density) volumes. We associate this high diffractivity to a variable pore fluid composition and saturation, which we infer to be due to hydrocarbon migration from the underlying strata. Consequently, we conclude poor seal quality for the underlying cap rocks.

During data processing, we test diffraction focusing analysis for velocity model building. This option appears quite valuable for P-Cable data processing because of short offset and limitations of the standard velocity analysis.